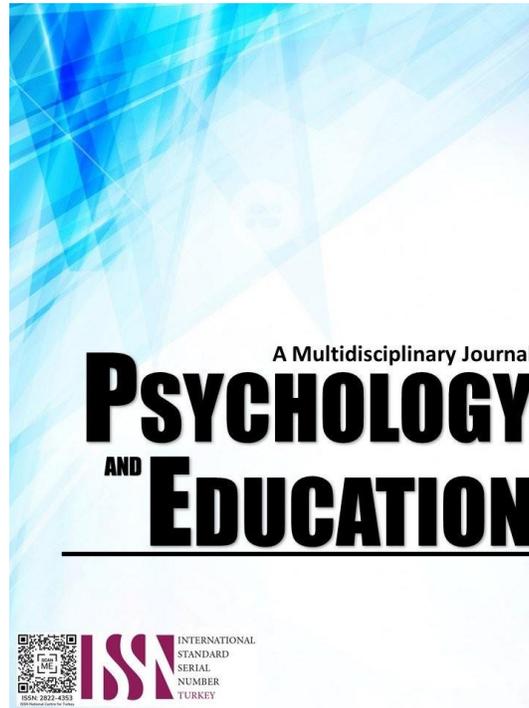


**ENHANCING THE MATHEMATICS PERFORMANCE LEVEL OF
GRADE 8 STUDENTS THROUGH THE NUMBER TOWER:
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Enhancing the Mathematics Performance Level of Grade 8 Students through The Number Tower: A Game-Based Intervention in Addition and Subtraction of Integers

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Abstract

The Number Tower is a game intended to improve the performance of Grade 8 students at J.P. Laurel High School for S.Y. 2024-2025 relative to the addition and subtraction of integers. The study used quasi-experimental and one-group pretest-posttest as a research design. The researchers employ a non-probability sampling technique specifically purposive sampling. The study utilized the multiple-choice questionnaire for the pre-test, implemented The Number Tower Game for intervention, and conducted the post-test and interview guide afterward. The results of the pre-test and post-test show an increase in students' performance from FS (Fairly Satisfactory) to S (Satisfactory) after the utilization of the game. The result of the t-test revealed that there is a significant difference between the pretest and posttest scores of the 25 students after the utilization of the game. This means that the utilization of The Number Tower is effective in improving the level of performance of the least performing students in the addition and subtraction of integers.

Keywords: *game-based, intervention, addition and subtraction of integers, performance level*

Introduction

Mathematics is not solely defined as a research discipline or a subject taught and learned at school, it also serves as an avenue for students, amateurs, and professionals, to be presented with mathematical challenges that can reflect reality. Additionally, it serves as an arena for competitions, offering a source of variety of problems including some of the hardest problems that science has to offer, at all levels from elementary school to the millennium problems (Csicsery, 2008; Ziegler, 2011).

There are various perceptions among students regarding mathematics. Some view it as a challenging but beneficial subject, while others find it boring and difficult. Students' personal experiences and perspectives, as well as the teaching methods employed by the teachers, are some of the factors that can influence student's perception of mathematics. In mathematics education, the approach used by teachers can significantly impact students' responses during learning sessions. Active learning can be fostered if teachers employ innovative and different approaches to mathematics instruction, departing from conventional methods (Taranto et al., 2021).

Different research was conducted to discuss and analyze the students' difficulties to perform addition, subtraction, multiplication, and division with natural numbers. Some of these research or experiences focused on students' errors in these operations, others have experience reports citing ways to overcome these difficulties. Thus, the findings highlight the importance of understanding the underlying causes of students' difficulties in performing basic arithmetic operations.

In this direction arises the article by Felicio and Policarpo (2015) entitled "The use of games as a teaching re-source" which presents the concept of an experiment that uses mathematical games as a teaching resource in the teaching learning process carried out with students from sixth grade of elementary education. These games were used as targets for students to solve using the four basic operations, addition, multiplication, division, and subtraction with natural numbers. The authors state that the use of games as a teaching and learning strategy in the classroom is a pedagogical resource that allows students to develop operations-solving methods with natural numbers. This aimed to stimulate the creativity and participation of the students because they had to make use of strategies to win the game, which allowed them to hone the skills that make up logical reasoning.

The current development of technology enables teachers to be more innovative in designing engaging learning methods that captivate students' interest. Gamification of learning is one strategy that can be used to make mathematics education more appealing and encourage student involvement. Research conducted by Oliveira et al (2020) has shown that gamification in education can make teaching activities more interesting, can enhance motivation, and can increase student engagement and attention.

Gamification is the process of integrating components of game design into situations that are not games, like education (Dustman et al., 2021). Based on past studies, it has been shown that games were widely liked and enjoyed, indirectly making them a popular choice among students. The integration of gamification in mathematics education has gained attention as a potentially effective tool to enhance the effectiveness of learning. As a result, gamification of mathematics has become an approach to transform conventional learning into digital games that can be accessed regardless of time and place. This approach aims to improve student's learning experiences, making it more engaging and interactive.

When teachers have limited time to help students maintain their mathematical skills, gamification can be an effective alternative. Krause et al. (2015) found that gamification improves students' knowledge retention by 25%, and adding game elements can increase this to 50%. According to Jung et al. (2021), integrating game elements motivates students, relaxes their minds, and reinforces learning habits. Gamification sparks curiosity, leading to greater interest in mathematics and active participation. Additionally, Dash et al.

(2022) highlight that gamification fosters social development through collaborative and competitive games while presenting math concepts enjoyably and interactively.

Incorporating game elements such as challenges, stages, and rewards into math education can motivate students to enhance their skills. Gamification helps improve problem-solving abilities (Abu-Hammad and Hamtini, 2023) as students must think critically, develop strategies, and apply math concepts to progress in games. According to Marin-Diaz et al. (2020), this approach promotes proficiency in problem-solving. Furthermore, An (2021) highlights that gamification enhances cognitive skills by requiring logical thinking, decision-making, and information analysis, ultimately fostering critical thinking and improving problem-solving capabilities.

One of the games we can use in math education is Jenga. Jenga is a popular block game played by two players. Each player in her turn has to remove a block from a stack, without toppling the stack, and then add it to the top of the stack. We analyze the game mathematically and describe the optimal strategies of both players (Zwick, 2002). The game of Jenga is a challenging game with significant physical intricacy. The game uses fifty-four hardwood blocks, stacked in groups of three oriented perpendiculars to the previous layer (Ziglar, 2006).

As games are now integrated in teaching and learning, a variety of available interactive games can be modified to cater mathematics education. One of the interactive games that a teacher can utilize is jeanga. Using Jenga in this study provides an engaging way to help Grade 8 students learn addition and subtraction of integers. This interactive approach encourages collaboration, boosts motivation, and enhances students' critical thinking and problem-solving skills. Additionally, teachers can observe how students tackle challenges during gameplay, offering valuable insights into their understanding.

This study can explore how Jenga may serve as an effective teaching tool, potentially transforming traditional methods. By engaging students through play, Jenga not only helps them grasp addition and subtraction of integers but also builds critical thinking, teamwork, and problem-solving skills. The use of gamification in education has been linked to increased motivation and retention, making it a valuable strategy for addressing diverse student needs and enhancing their experiences in learning mathematics (Dustman et al., 2021).

The aim of this study is to evaluate how effective The Number Tower is as a teaching tool for helping Grade 8 students learn addition and subtraction of integers. It focuses on measuring students' performance before and after playing the game to determine any notable improvements in their mathematical skills and problem-solving abilities. In light of this, the results may contribute to the development of innovative teaching methods that enhance students' learning experiences in mathematics.

Research Questions

The study aims to determine the effectiveness of the game “The Number Tower” in improving the performance level of selected Grade 8 students at J.P. Laurel High School in addition and subtraction of integers. Specifically, it sought to answer these questions:

1. What is the performance level of grade 8 students before the conduct of the number tower?
2. What is the performance level of grade 8 students after the conduct of the number tower?
3. How significant is the difference in performance level before and after the conduct of the number tower?
4. What are the experiences of grade 8 students in using the number tower?

Literature Review

Mathematics is one of the important subjects in primary schools, which can be a criterion for evaluating the ability of student's level learning and understanding. However, some students feel anxious or demotivated in learning mathematics. Moreover, their failure in mathematics may influence their grasp of other scientific subjects. For these reasons, the teachers should be teaching mathematics carefully and use modern methodologies for teaching mathematics (Alshatri, Wakil, Bakhtyar, 2019). Research revealed that students faced problems in understanding the concept in adding and subtracting integers. A lack of foundation skills in mathematics, which includes the computations of integers, caused many Brunei upper secondary students unable to solve algebraic equations. Moreover, a local study discovered that more than 50% of the grade 7 students in one government school failed in the computation of integers (N Sahat et. Al, 2018).

These literatures show the importance of using game-based methods to help students understand adding and subtracting integers. It highlights that students often feel nervous and struggle with basic math skills, which is why creative, game-based learning tools like Math Jenga are valuable for they can be perceived as tools that can change students' perceptions towards learning mathematics. These tools can boost students' skills and confidence in working with integers.

Teaching mathematics is a system of concepts, theories, methods, and teaching activities. Mathematics is not only the abstract study of numbers, space, and change but also the paradigms for proving hypotheses by mathematical inferences and the application of knowledge to problems in different areas of life. The method in teaching is one of the factors that determine the quality of education in general and is a key pedagogical element to ensure effective teaching. The teaching method will determine the effectiveness of learning and applying mathematics in different real-life circumstances. The teachers can organize learning tasks or exercises to deepen learned knowledge, develop and operate higher order thinking skills, and apply math knowledge in practice (Hoang et. al 2023). Instructional materials are components that make mathematics teaching and learning enjoyable and rewarding. Today's successful

mathematics teachers can use game-based learning instructional resources to express ideas and pique student's interest. Mathematics teachers consider how they may use game-based learning instructional resources to teach arithmetic to students. The teachers can overcome this challenge by using technology-based programs that have been scientifically verified and are based on research on how students acquire specific topic (Clements & Wright 2022). These literatures emphasize that teaching methods play a big role in the quality of education, especially in math. Effective math teaching includes methods that help students connect what they learn with real-life applications. Tools like games and interactive materials make learning math more enjoyable and engaging. Game based methods, for instance, can spark students' interest and help them understand math better concepts better.

Learning with the game is very motivating and fun (Sari 2018), allowing students to develop their interest and enthusiasm in learning math. These factors make Jenga a practical alternative in teaching specific math concepts. Thus, using Jenga in adding and subtracting integers can motivate students to learn and improve their skills in integer operations. Game-based learning is becoming a "way of teaching in education" and consists of two types: (1) digital game-based learning and (2) non-digital game-based learning (Naik, 2015). Although non-digital game-based learning is the "less popular" form of game-based learning, it serves as a "vital part of teaching tools in education (Naik, 2015). Playing mathematical games are created not only to amuse students but also to provide a strong motivation for students (Balbuena & Buayan, 2015). Games can be used to teach integers. When students play, their retention becomes better (Duncan, 2019). They think about how to win a game and if a mathematical skill is a part of playing the game, they see a quick application of it and thus, unconsciously remembering the rules faster. In the study of Balbuena and Buayan (2015), they found out that with the invention of the integer operation (INTOP) card game, students can actively construct their own knowledge and use it in a traditional approach.

According to Dondio et al. (2022) when games are encouraged in a classroom setting, teamwork and social contact will be developed, and math anxiety will be reduced more effectively. Game-based learning will significantly enhance the teaching-learning process in mathematics and one that can be applied in the classroom with ease. This provides support and promote learners' motivation for games are a highly effective part of this teaching technique. It is a technique that uses the notion of playing a game to fulfill learning goals, whether they related to knowledge, abilities, or attitudes (Falciani, 2020). Educational games when successfully employed in teaching can enhance mathematical learning skills (Hasanah & Andayani, 2022). Persky (2013), asserted that game-based math instruction has demonstrated positive benefits in terms of motivation, engagement, and learning outcomes. Games can increase students' intrinsic motivation and pleasure in mathematics learning. For students to experiment, make judgments, and feel the effects of those decisions, games offer a dynamic and safe environment, which fosters critical thinking and problem-solving abilities (Barb et al. 2014).

A study by Abawi and Biehler (2014), evaluated the impact of a scaffolded math game-based learning environment on a traditional learning environment on students' academic achievement. The outcomes demonstrated that, in comparison to the traditional learning environment, the game-based learning environment had an overall favorable impact on academic performance. The findings of the aforementioned studies suggested that in terms of motivation, performance, and learning satisfaction, game-based mathematics learning is superior to conventional teaching techniques. Additionally, encouraging academic accomplishment through game-based learning is more successful, especially with kids who have no prior arithmetic background. According to a study by Kay and Barb (2016), game-based math instruction can help students' procedural fluency, conceptual understanding, and mathematical knowledge. In contrast to traditional training, students who participated in game-based mathematics learning had significantly higher levels of mathematical proficiency. The study also emphasized how engaging and enjoyable games are for students when learning math.

Game-based learning is gaining importance in education because it helps engage students, increase motivation, and improve learning, especially in math. Both digital and non-digital games create interactive experiences that help students remember concepts better. Research shows that games can reduce anxiety, promote teamwork, and make learning more enjoyable, making them valuable tools for teachers, particularly for students who need extra support. Studies show that playing math games helps students remember what they learn, reduces anxiety, and encourages critical thinking. Research indicates that games can improve math skills, making it easier for students to understand concepts and solve problems. Overall, game-based learning is often more effective than traditional teaching, especially for students who are less familiar with math.

Methodology

Research Design

The study used a quasi-experimental design, which is appropriate for investigating the performance level of Grade 8 Students in adding and subtracting integers through the number tower. A quasi-experimental design allows the researchers to investigate the effect of The Number Tower on students' performance levels in adding and subtracting integers by comparing results before and after its conduct. The design facilitates the use of pre-test and post-test assessments, enabling a structured comparison to detect any significant changes in students' performance in integer addition and subtraction as a result of engaging in The Number Tower activity.

Respondents

The respondents of this study are the selected 25 Grade 8 students of J.P. Laurel High School during the school year 2024-2025. A purposive sampling method was employed, specifically selecting students based on their low mathematics grades.

Instrument

The main instruments used to gather the data from the respondents were 20-item pre-posttest about addition and subtraction of integers and an interview guide. This was done to measure any changes in performance after participating in The Number Tower intervention.

The Number Tower

A. Materials

- Jenga pieces – 54 Jenga pieces with numbers from -10 to 10.
- Operation Cards – 42 cards of which 21 have addition signs and 21 have subtraction signs.
- Dice – standard six-sided dice
- Score sheet

B. Mechanics of the Game

The game The Number Tower is intended to develop mastery of the computational skill of the students on the topics relative to addition and subtraction of integers. For the players to win, they must collect a large number of points at the end of the game.

Two to four players are needed to play the game. The game comes with 54 jenga pieces, 42 cards, and a pair of dice. Each jenga piece is denoted by an integer and cards have either addition or subtraction signs. These cards will be given to the four players at the start of the game. A score sheet is also included to record the players' scores for each round in order to determine the game's winner.

To start, each player will be given 3 random cards.

1. To start the game, build the tower using the Jenga pieces grouped in threes to form 18 stories. Each story is stacked and must be placed in alternate directions by 90 degrees so that each story above and below is perpendicular to it.
2. To determine who goes first in The Number Tower, players will roll a die. The player with the highest roll goes first, and the order continues counterclockwise.
3. The first player will remove one block below the highest level of the Jenga tower and records it as their score.
4. Next, the second player will also remove one block from the tower, select a card from what the player is holding then solve the two succeeding block numbers based on the operation written on a card. The player will have 1 minute to pull a block and solve the operation. If the player does not finish within the given time, they will be deducted 5 points and must pick another card from the deck.
5. The players will continue the game, stopping only if the number tower falls. The player whose turn causes the tower to fall will be deducted 20 points.
6. The player with the highest positive score will be the winner of the game.

Testing the Functionality of the Game

To determine the performance level of the students before and after the conduct of the game, mean and standard deviation were used on the scores on pre-test and post-test. The qualitative interpretation is given as follows: 0-4 - Did not meet expectations, 5-8 - Fairly Satisfactory, 9-12 – Satisfactory, 13-16 - Very Satisfactory, and 17-20 – Outstanding.

To know the functionality of the game, paired t-test were used to know if there is a significant difference between the scores on pre-test and post-test with 0.05 level of significance. Also, a thematic analysis was used to analyze the experiences and perspectives of grade 8 students in playing The Number Tower.

Procedure

Data were collected in three phases. First, all Grade 8 students took a pretest on addition and subtraction of integers to establish a baseline. Next, students participated in the The Number Tower activity during regular math classes. After the intervention, a posttest was administered to assess improvements. Additionally, a focus group discussion with eight selected students was conducted to gather qualitative insights on their experiences and engagement with the activity.

Ethical Considerations

Strict ethical guidelines, therefore, governed the conduct of this study to ensure the utmost protection and confidentiality of participants. All students are expected to provide informed consent; for those below 18 years, parental consent is required. Participants will be informed of the purpose of the study and their rights to withdraw at any time with full assurance of complete anonymity and confidentiality of their responses. The information gathered was for research purposes only, and private details were kept confidential and on a safe database. In addition, care was taken not to disrupt the students' schedules of studying because they would have otherwise been occupied in their schools.

Results and Discussion

Performance level of Grade 8 students on addition and subtraction of integers before the conduct of The Number Tower

Table 1. Descriptive statistics on the performance level of Grade 8 students before the conduct of The Number Tower

Type of Test	Mean	Standard Deviation	Description
Pretest	6.30	1.725	Fairly Satisfactory

Note: 0-4: Did not meet expectations; 5-8: Fairly Satisfactory; 9-12: Satisfactory; 13-16: Very Satisfactory; 17-20: Outstanding

The performance level of Grade 8 students on addition and subtraction of integers before the implementation of The Number Tower was assessed through a pretest. Table 1 displays the descriptive statistics for this assessment. The mean score for the pretest was 6.30, with a standard deviation of 1.725. According to the interpretation scale, this mean score fell within the "Fairly Satisfactory" range (5-8), indicating that students demonstrated a basic understanding of integer operations but with room for improvement. The relatively low mean score suggested that prior to using The Number Tower, students had only a moderate grasp of addition and subtraction of integers, underlining a need for instructional support to enhance their proficiency in these fundamental skills.

Performance level of Grade 8 students on addition and subtraction of integers after the conduct of The Number Tower

Table 2. Descriptive statistics on the performance level of Grade 8 students after the conduct of The Number Tower Game

Type of Test	Mean	Standard Deviation	Description
Posttest	9.47	2.080	Satisfactory

Note: 0-4: Did not meet expectations; 5-8: Fairly Satisfactory; 9-12: Satisfactory; 13-16: Very Satisfactory; 17-20: Outstanding

Effectiveness of The Number Tower in Solving Addition and Subtraction of Integers

Table 3. Analysis of the difference between the pretest and posttest scores of students on solving addition and subtraction of integers

Type of test	Mean	Standard Deviation	t-value	Sig-value	Interpretation	Decision to Null
Pretest	6.30	1.725	-8.899	.000	Significant	Reject
Posttest	9.47	2.080				

$\alpha = 0.05$ Level of Significance

Table 3 presents the analysis of the difference between the pretest and posttest scores of Grade 8 students on solving addition and subtraction of integers. The mean score for the pretest was 6.30 with a standard deviation of 1.725, while the mean score for the posttest increased to 9.47 with a standard deviation of 2.080. A paired t-test was conducted to determine the significance of the difference between these scores. The calculated t-value of -8.899, with a corresponding p-value of .000, was less than the established alpha level of 0.05, indicating a statistically significant difference. This result led to the rejection of the null hypothesis, suggesting that the intervention, The Number Tower, had a significant positive impact on students' performance in addition and subtraction of integers.

Experiences of Grade 8 students on the use of Math Jenga

A thematic analysis of the focus group discussion with eight Grade 8 students about their experiences using Math Jenga revealed several key themes regarding its impact on learning, engagement, and collaborative skills. The analysis is organized into the following themes:

Table 4. Thematic Analysis of the experiences and impressions of Grade 8 students on the use of The Number Tower

Condensed Meaning Unit	Codes	Themes
"It was easier to remember how to add and subtract when we did it while playing."	Improved understanding	Enhanced Understanding of Integer Operations
"The Number Tower made math feel less scary and more fun."	Reduced math anxiety	Reduction in Math Anxiety
"I looked forward to Math class because of The Number Tower."	Increased motivation	Increased Engagement and Motivation
"It was helpful to talk with friends about each move and correct each other."	Peer support, collaboration	Peer Collaboration and Teamwork
"Sometimes we got too focused on not letting the tower fall, and I forgot about the math part."	Distraction from math content	Challenges in Game Mechanics and Focus
"I liked discussing the problems with others to make sure we got it right."	Group problem-solving	Peer Collaboration and Teamwork
"The game was fun and made me want to practice more."	Enjoyment of learning, practice	Increased Engagement and Motivation
"Working in teams helped me understand the math better."	Group understanding	Enhanced Understanding of Integer Operations
"I felt like I learned better because we were doing something hands-on."	Hands-on learning, retention	Enhanced Understanding of Integer Operations
"Sometimes we got carried away with the game and forgot the	Difficulty focusing	Challenges in Game Mechanics and

Table 4 reveals several significant themes from the focus group discussion on the use of The Number Tower to support learning addition and subtraction of integers. A prominent theme was the Enhanced Understanding of Integer Operations, as students found that the hands-on, interactive format of The Number Tower helped them grasp mathematical concepts more effectively. Responses such as "Mas nadumduman po namo an pag add and minus pag nag uuyag" (It was easier to remember how to add and subtract when we did it while playing) highlighted how the physical engagement of moving blocks reinforced their understanding and retention of integer rules.

Another key theme was Increased Engagement and Motivation. Many students noted that The Number Tower made learning more enjoyable, stating, "Gusto ko po magsulod na sa Math kay mauyag na sun" (I looked forward to Math class because of The Number Tower). This suggested that the game's structure created a fun, stimulating environment that encouraged students to participate actively and even sparked a desire to practice math more frequently.

Peer Collaboration and Teamwork also emerged as an important theme, as students frequently mentioned the benefits of working together to solve problems. Responses like "Mas nakadanon po pag nag iiristoryahan kami kay natatama po nira an answer" (It was helpful to talk with friends about each move and correct each other) indicated that The Number Tower promoted a collaborative learning atmosphere, enabling students to support and learn from one another.

Additionally, several students expressed a Reduction in Math Anxiety, sharing that the game made math feel "less scary and more fun." This theme pointed to The Number Tower's ability to create a relaxed environment that eased the pressure typically associated with math, allowing students to engage without the fear of failure.

However, there were some challenges in Game Mechanics and Focus, as a few students noted that the excitement of keeping the number tower stable sometimes detracted from their focus on the math problems. Statements like "Nakafocus po ako para diri matumba an tower, minsan nalilimutan ko po magsolve" (Sometimes we got too focused on not letting the tower fall, and I forgot about the math part), suggested that while The Number Tower was engaging, it occasionally shifted attention away from the primary learning objective.

Overall, this qualitative analysis supported the quantitative results, showing that The Number Tower positively impacted students' understanding, motivation, collaboration, and confidence in math, although minor adjustments could enhance its focus on educational content.

Conclusions

Based on the findings of the study, it can be concluded that the use of the game The Number Tower significantly increased the performance level of Grade 8 students and is effective in improving the performance of the least performing students in addition and subtraction of integers. To further test the effectiveness of the game The Number Tower, a more thorough experimental research design may be conducted. Additionally, this game could serve as a reference in creating more math-related learning materials to enhance students' performance. Finally, future studies related to gamification may be undertaken by covering other learning competencies in Mathematics.

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